Modeling the time-dependent rheological behavior of complex soft materials: elasticity, viscoplasticity, thixotropy, and irreversibility

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A wide range of soft materials undergo irreversible processes of either a chemical or physical nature and present a complex transient rheological behavior, which cannot be properly described by existing constitutive models. In this work, a recently proposed time-dependent constitutive model [Marchesini et al., J. Rheol. 63(2), 247-262 (2019)] that can take into account elasticity, viscoplasticity, thixotropy, and irreversibility is improved and discussed in detail. The model is based on a single scalar structure parameter and composed by one differential equation relating the shear rate to the stress, one equation describing the evolution of the structure of the material, and one equation describing the progress of each irreversible process. The predictions of the model for different rheometric flows are compared to rheological data available for materials undergoing either chemical reactions or irreversible shear degradation. It is shown that the model describes the complex transient behavior observed in an unprecedented fashion, which has the potential to impact a myriad of applications in different industries.